Results of First Wire Scans of HINS 2.5 MeV Beam

Summarized by Bob Webber, January 19, 2010

Introduction

The first accelerated beam from the Fermilab HINS 325MHz RFQ was obtained on Wednesday, January 13, 2010. The first attempt to measure the transverse profile of the beam with wire scanners was made on Friday, January 15. This memo summarizes the wire scan efforts.

Operating Conditions for Wire Scans

The 2.5 MeV beam was run at 2-3 mA in 50 microsecond pulses at 0.5 Hz. Only the first wire scanner, ~12 inches immediately downstream of the RFQ, was operated with the beam running. The scanner consists of three wires to obtain horizontal, vertical and diagonal profiles. Motion is orthogonal to the diagonal scanning wire and at 45 degrees to both the horizontal and vertical scanning wires.

First Observations

The first method to obtain the profiles was to run the wire scanner control, data acquisition and display program previously used for ion source beam scans. These initial scan attempts produced confusing results. The signals manifested unexpected behavior as a function of time and amplitudes much larger than expected. These observations suggested that the signal amplifiers were saturating during the time of the 50 microsecond RFQ pulse when 2.5 MeV beam should be expected. In addition, much smaller signal was also observed with a duration corresponding to the 500-microsecond ion source beam pulse. There was also a problem with the data display page not updating properly.

These issues led us to remove the signals from the digitizer boards and look at them directly on an oscilloscope. While observing in this manner, the wire scanner was manually stepped across the aperture in position increments corresponding to 0.5 volt position read back changes. In this way, we confirmed that the signals during the time of the accelerated beam were driving the amplifiers at the wire scanners far into saturation. We also confirmed that with this gain a small beam signal throughout the duration of the ion source pulse is observable downstream of the de-energized RFQ. (Changing nothing else, we observed that signal disappear when we closed the beam stop between the source and the RFQ!)

Finally, the amplifiers were removed from the circuit and the signals from the wires were directly connected into 50 ohms at the oscilloscope. With this configuration, signals with the expected time structure were observed at the level of a few millivolts.

Results

Oscilloscope Channels 1, 2, and 3 correspond to the three wires in the scanner. Channel 1 represents the diagonal profile and (to be confirmed) Channel 2, the horizontal profile, and Channel 3, the vertical profile.

Plots in Figures 1-3 show the scan results for three conditions:

- Signals through amplifier observed 'in-time' with the RFQ
- Signals through amplifier observed during ion source beam time but 'out-of-time' with the RFQ
- Signals directly into 50 ohms without amplifier observed 'in-time' with the RFQ

Plots in Figures 4-6 display the same data, but each plot shows just one wire for all three conditions.

In all plots, the horizontal scale is the wire position readback in units of volts. The readback calibration for the diagonal wire is 10.3 mm/volt. Since scanner motion is normal to the diagonal wire and at 45 degrees to the horizontal and vertical wires, the motion of the horizontal and vertical wires is 7.3 mm/volt.

Discussion

Figure 1 clearly shows the amplifier saturation effect with signals topping out at ~14 volts. Figure 2 shows that respectable signals were observed from beam 'out-of-time' with the RFQ pulse. Figure 3 portrays the best beam profiles obtained. The physical beam size in each projection is approximately 20 mm at the base. The apparent 'shoulders' on the inner sides of the channel 2 and 3 profiles suggest possible cross-talk between wires. Figures 4-6 show consistent beam center locations for each of the three observing conditions, including that of the non-accelerated ion source beam.

Plans

The signal amplifiers are being modified for suitable gain and bandwidth parameters. Bug fixes have been made to the wire scanner control and display application. We plan to check out these improvements and then proceed with scans of finer step size. We will expand the effort to include the two scanners farther downstream in the beam line. We will verify which profile is horizontal and which is vertical. We will investigate the shoulders on the horizontal and vertical profiles.

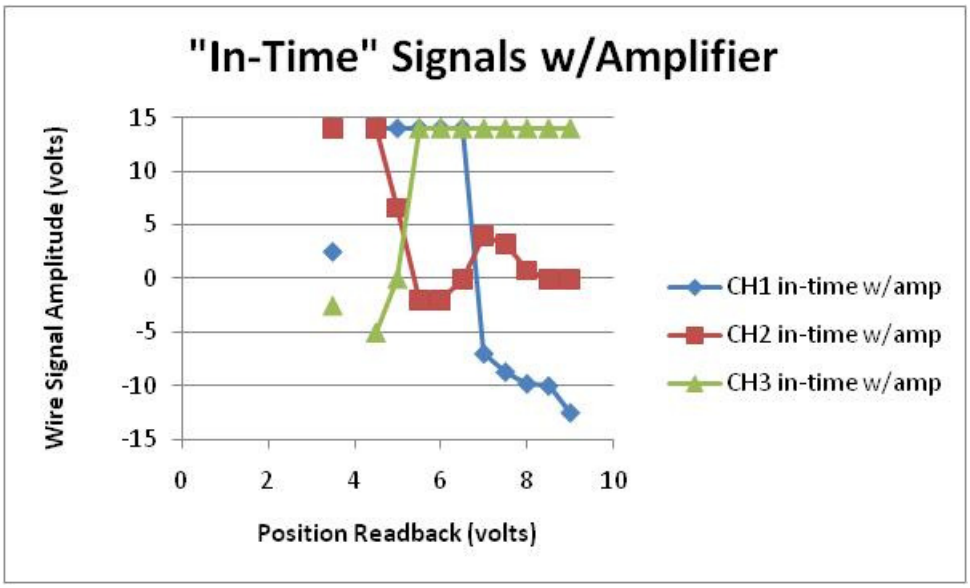

Figure 1. "In-Time" (accelerated beam) Scan Results with Amplified Signals

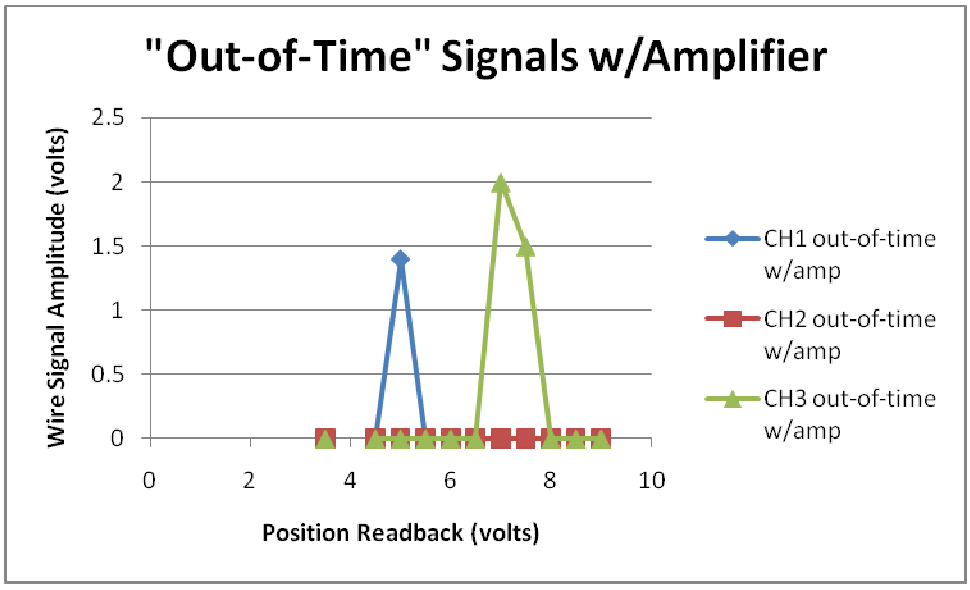

Figure 2. "Out-of-Time" (Ion source beam) Scan Results with Amplified Signals

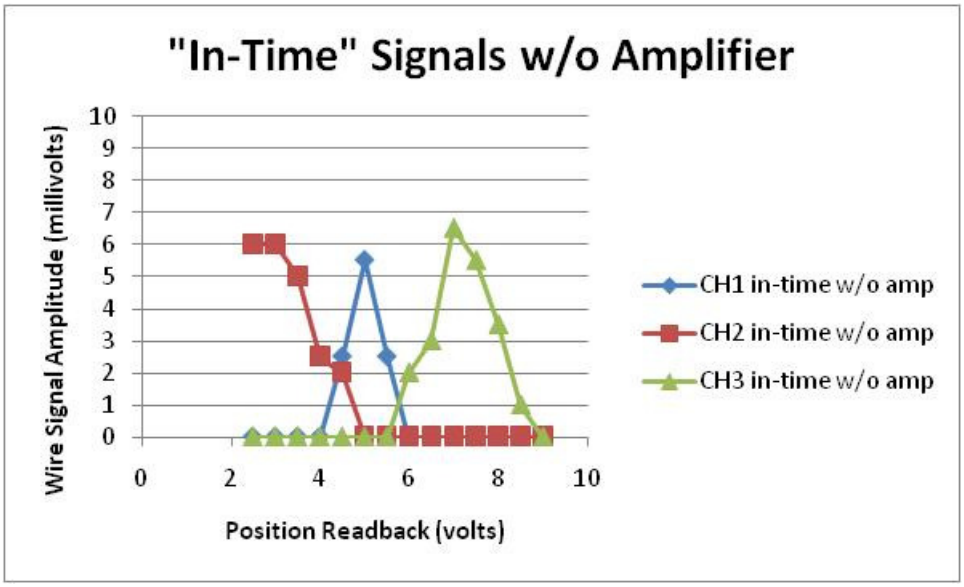

Figure 3. “In-Time” (accelerated beam) Scan Results with Unamplified Signals

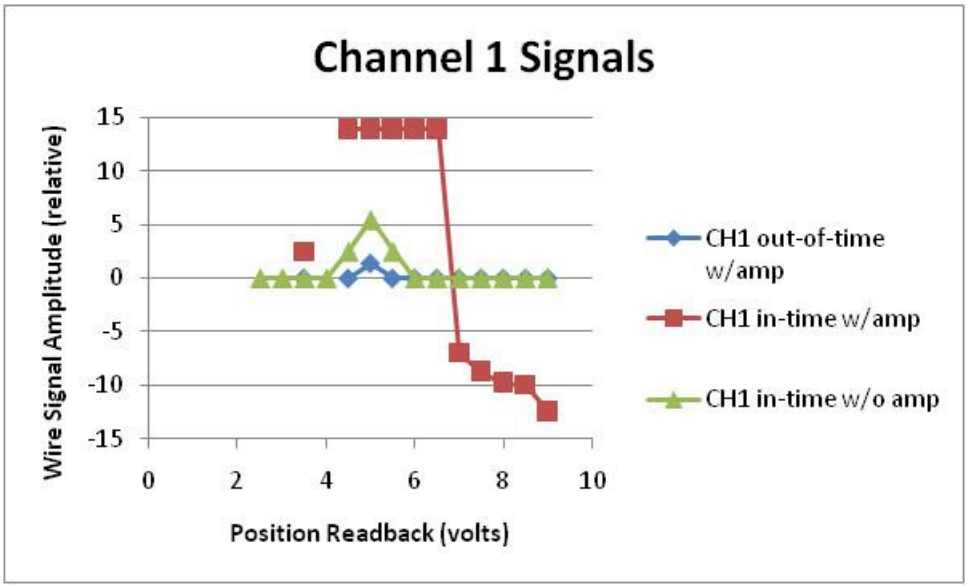

Figure 4. Channel 1 (diagonal wire) Scan Results for Three Conditions

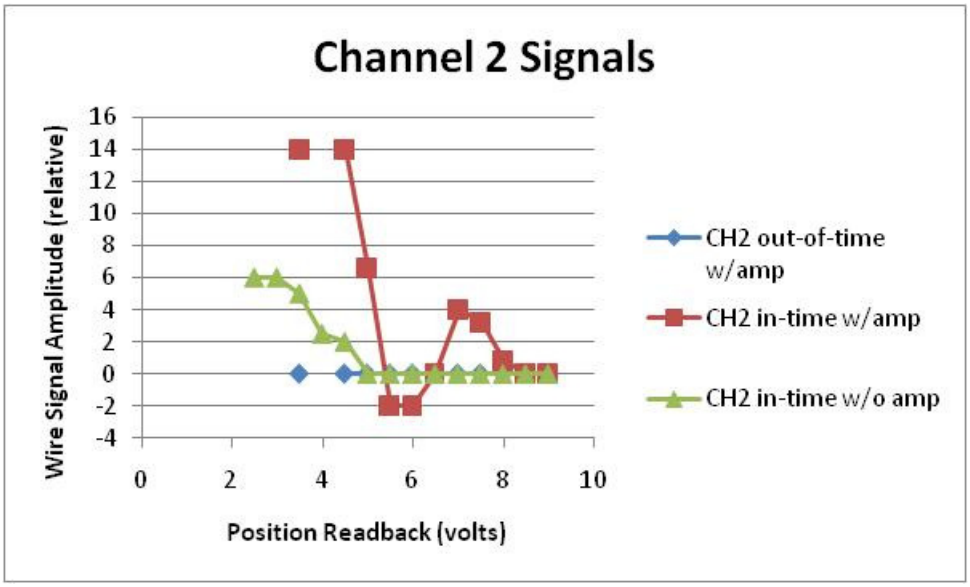

Figure 5. Channel 2 (Horizontal Profile?) Scan Results for Three Conditions

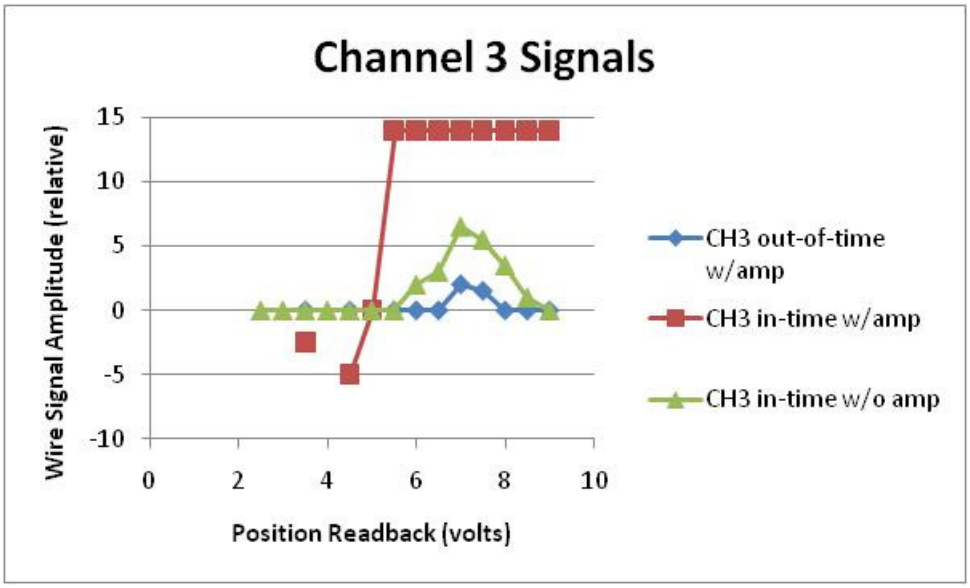

Figure 6. Channel 3 (Vertical Profile?) Scan Results for Three Conditions